

# NASA-DoD Lead-Free Electronics Project

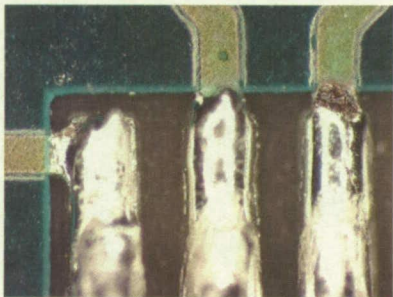
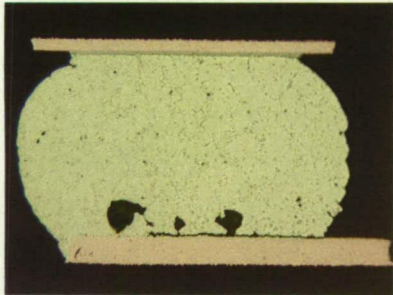
BAE SYSTEMS



COM DEV

Rockwell  
Collins

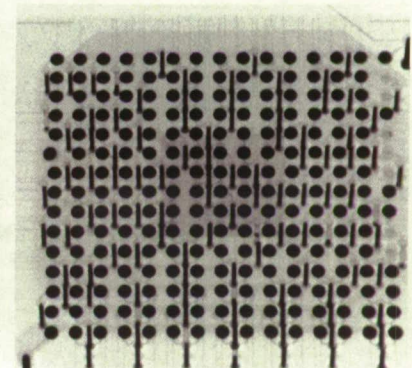
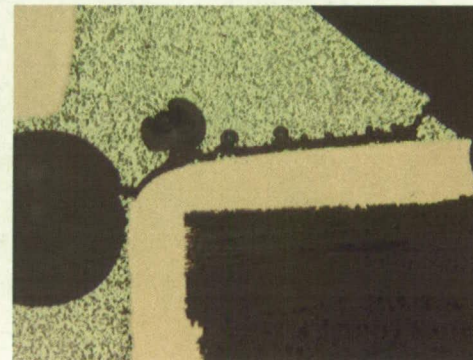
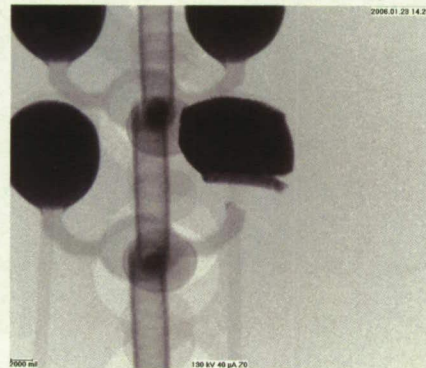
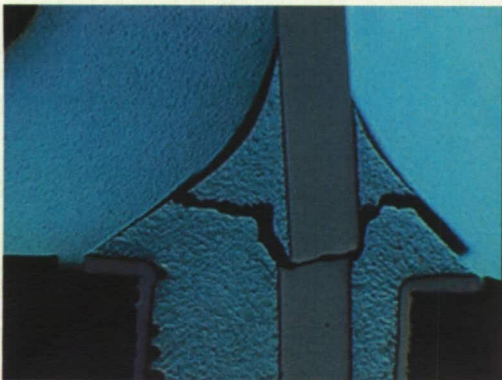
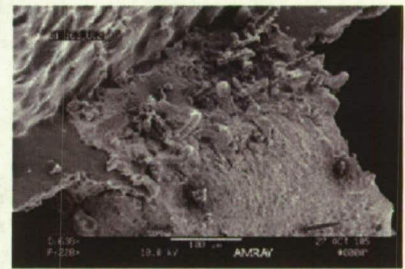
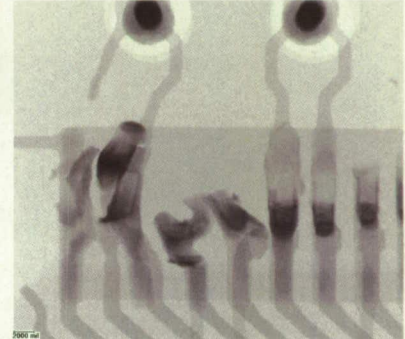
Raytheon



calce



ITB inc.



TEXAS INSTRUMENTS

BOEING

CELESTICA

HARRIS





# NASA-DoD Lead-Free Electronics Project

The primary technical objective of the project is to undertake comprehensive testing to generate information on failure modes/criteria to better understand the reliability of:

- Packages (e.g., TSOP, BGA, PDIP) assembled and reworked with lead-free alloys
- Packages (e.g., TSOP, BGA, PDIP) assembled and reworked with mixed (lead/lead-free) alloys

## Web Link:

**NASA-DoD Lead-Free Electronics Project:**  
[http://acqp2.nasa.gov/projects/NASALeadFreeElectronics\\_Proj2.html](http://acqp2.nasa.gov/projects/NASALeadFreeElectronics_Proj2.html)

# Comparison of NASA-DOD LFE Project to predecessor JCAA/JG-PP Project

## •Similarities

- Virtually identical test vehicle
- Procedures identical for most tests
- Same facility for assembly
- SN100C being used for wave soldering

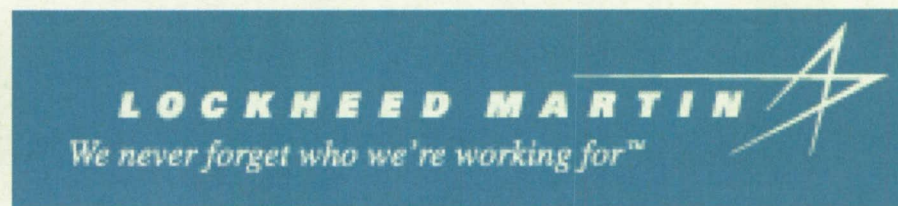
## •Differences

- Test articles will be thermally aged after assembly
- Increased Rework
- Increased solder mixing
- Mechanical shock test procedure
- Drop Testing
- Immersion Ag surface finish for all test vehicles
- SAC305 being used for reflow soldering
- SN100C being used for reflow soldering

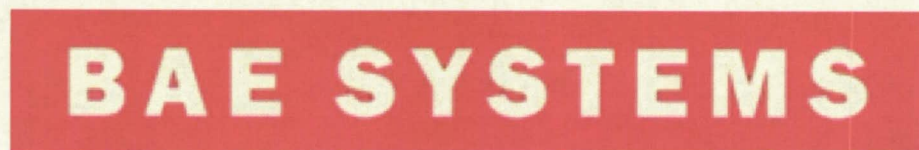
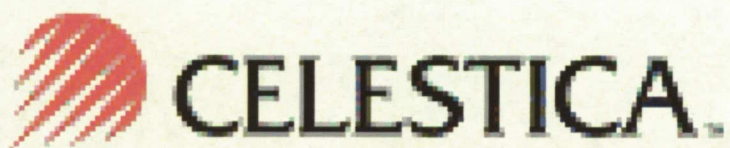




# NASA-DoD Lead-Free Electronics Project Stakeholders



**Rockwell  
Collins**



**calce<sup>TM</sup>**  
**Raytheon**



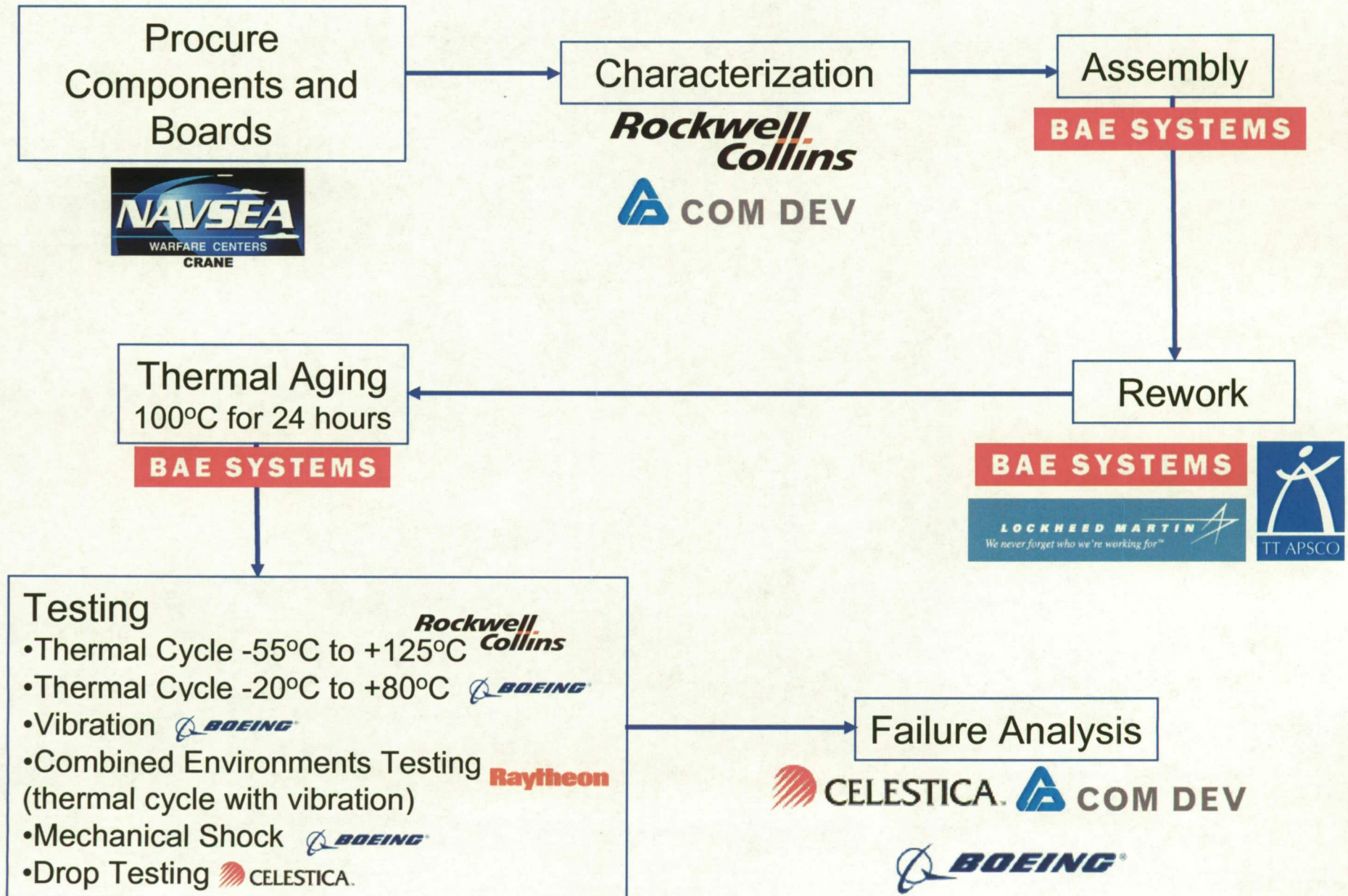
**HARRIS**



**U.S. AIR FORCE**



# Project Flow





# Lead-Free Solder Alloys

## **SAC305 (Sn3.0Ag0.5Cu)**

### **– Surface mount assembly**

This alloy was chosen for reflow soldering because this particular solder alloy has shown the most promise as a primary replacement for tin-lead solder. The team decided that they wanted to select at least one “general purpose” alloy to be evaluated and it was determined that the SnAgCu solder alloy would best serve this purpose.

## **SN100C (Sn0.7Cu0.05Ni+Ge)**

### **– Plated through hole**

### **– Surface mount assembly**

This alloy is commercially available and the general trend in industry has been switching to the nickel stabilized tin-copper alloy over standard tin-copper due to superior performance. In addition, this nickel-stabilized alloy does not require special solder pots and has shown no joint failures in specimens with over 4 years of service.



# Components & Component Finishes

Component	Component Finish	Note
CLCC	Au	Convert finish to SAC305; dipping lead to component body
CLCC	Au	Convert finish to SnPb; dipping lead to component body
QFN	Matte Tin	
QFN	SnPb	
TQFP - 144	NiPdAu	
TQFP - 144	Matte Tin	Convert finish to SAC305; dipping lead to component body
TQFP - 144	Matte Tin	Convert finish to SnPb; dipping lead to component body
BGA – 225	SAC405	
BGA – 225	SnPb	
DIP - 20	Matte Tin	
DIP - 20	NiPdAu	
CSP - 100	SAC105	
CSP - 100	SAC405	
CSP - 100	SnPb	
TSOP-50	SnBi	
TSOP-50	Matte Sn	



# Test Vehicle Assemblies

## 4 Main Categories

- SnPb Manufactured
- Lead-Free Manufactured
- SnPb Rework
- Lead-Free Rework



# Assembly Profiles

SnPb Manufactured Test Vehicles	
Surface Finish	Immersion Ag
Solder Alloy	
Reflow = SnPb	Wave = SnPb
Reflow Profile:	Wave Profile:
Preheat = ~ 120 seconds @140 183°C	Solder Pot Temperature = 250°C
Peak temperature = 225°C	Preheat Board T = 101°C
Time above reflow = 60-90 sec	Peak Temperature = 144°C
Ramp Rate = 2-3 °C/sec	Speed: 110 cm/min



# Assembly Profiles

Lead-Free Manufactured Test Vehicles	
Surface Finish	Immersion Ag
Solder Alloy	
Reflow = SAC305	Wave = SN100C
Reflow Profile:	Wave Profile:
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow: ~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min
Solder Alloy	
Reflow = SN100C*	Wave = SN100C
Reflow Profile:	Wave Profile:
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow: ~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min
* = Limited number of test vehicles being built, 16	



# Assembly Profiles

SnPb Rework Test Vehicles	
Surface Finish	Immersion Ag
	ENIG*
Solder Alloy	
Reflow = SnPb	Wave = SnPb
Reflow Profile:	Wave Profile:
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow: ~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min
* = Limited number of test vehicles being built, 8	

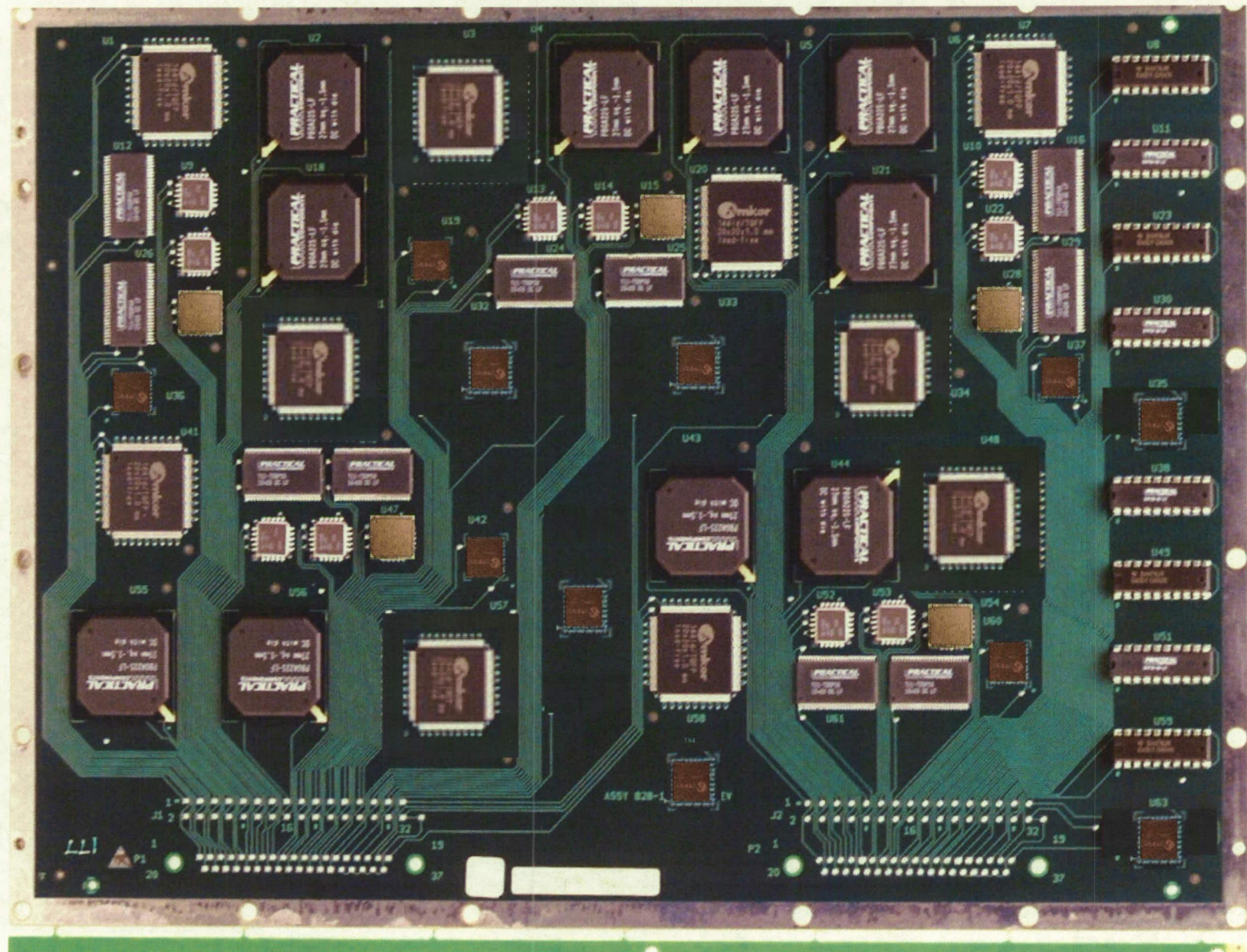


# Assembly Profiles

Lead-Free Rework Test Vehicles	
Surface Finish	Immersion Ag
Solder Alloy	
Reflow = SAC305	Wave = SN100C
Reflow Profile:	Wave Profile:
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow:~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min



# Test Vehicle





# Manufactured Test Vehicles

## Component Finish/Solder Combinations

### Thermal Cycle & Combined Environments Testing

SnPb Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SAC405	SnPb	
BGA-225	SnPb	SnPb	
CLCC-20	SAC305	SnPb	
CLCC-20	SnPb	SnPb	
CSP-100	SAC105	SnPb	
CSP-100	SnPb	SnPb	
PDIP-20	NiPdAu		SnPb
PDIP-20	Sn		SnPb
QFN	Matte Sn	SnPb	
TQFP-144	Matte Sn	SnPb	
TQFP-144	SnPb Dip	SnPb	
TSOP-50	SnBi	SnPb	
TSOP-50	SnPb	SnPb	

LF Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SnPb	SAC305	
BGA-225	SAC405	SAC305	
CLCC-20	SnPb	SAC305	
CLCC-20	SAC305	SAC305	
CSP-100	SnPb	SAC305	
CSP-100	SAC105	SAC305	
PDIP-20	NiPdAu		SN100C
PDIP-20	Sn		SN100C
QFN	Matte Sn	SAC305	
TQFP-144	SnPb Dip	SAC305	
TQFP-144	Matte Sn	SAC305	
TSOP-50	SnPb	SAC305	
TSOP-50	SnBi	SAC305	



# Manufactured Test Vehicles

## Component Finish/Solder Combinations

### Vibration and Mechanical Shock Testing

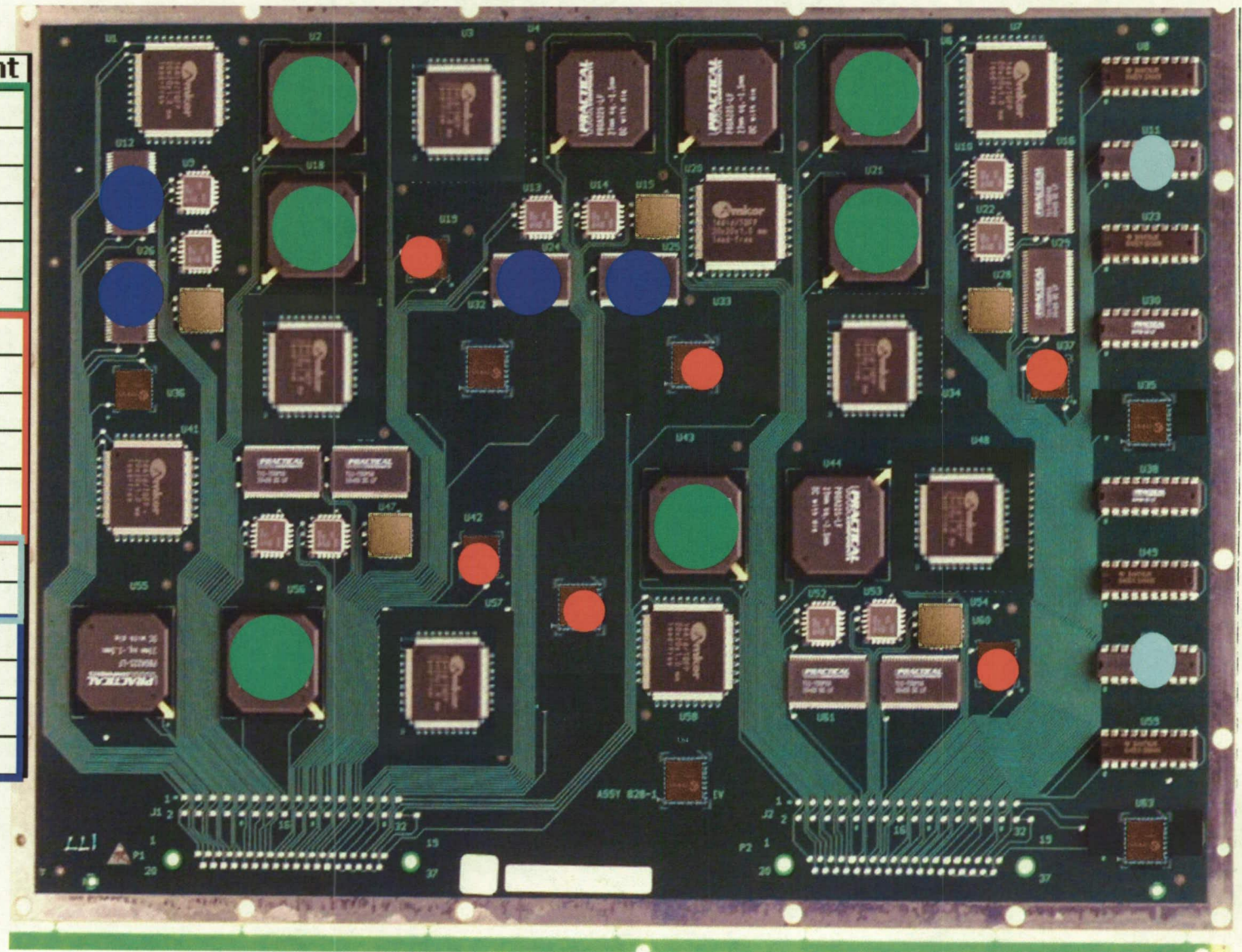
SnPb Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SnPb	SnPb	
CLCC-20	SnPb	SnPb	
CSP-100	SnPb	SnPb	
PDIP-20	SnPb		SnPb
QFN	SnPb	SnPb	
TQFP-144	Matte Sn	SnPb	
TSOP-50	SnPb	SnPb	

LF Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SAC405	SAC305	
CLCC-20	SAC305	SAC305	
CSP-100	SAC105	SAC305	
PDIP-20	Sn		SN100C
PDIP-20	NiPdAu		SN100C
QFN	Matte Sn	SAC305	
TQFP-144	Matte Sn	SAC305	
TSOP-50	SnBi	SAC305	
TSOP-50	Sn	SAC305	



# Components to be Reworked

RefDes	Component
U18	BGA-225
U43	BGA-225
U06	BGA-225
U02	BGA-225
U21	BGA-225
U56	BGA-225
U33	CSP-100
U50	CSP-100
U19	CSP-100
U37	CSP-100
U42	CSP-100
U60	CSP-100
U11	PDIP-20
U51	PDIP-20
U12	TSOP-50
U25	TSOP-50
U24	TSOP-50
U26	TSOP-50





# SnPb Rework Test Vehicles

SnPb Rework				
Component	Original Component Finish	Original Solder Alloy	New Component Finish	Rework Solder
BGA-225	SnPb	SnPb	SnPb	Flux Only
BGA-225	SAC405	SnPb		
BGA-225	SnPb	SnPb	SAC405	SnPb
CSP-100	SnPb	SnPb	SnPb	Flux Only
CSP-100	SAC105	SnPb		
CSP-100	SnPb	SnPb	SAC105	SnPb
TSOP-50	SnPb	SnPb	SnPb	SnPb
TSOP-50	Sn	SnPb		
TSOP-50	SnBi	SnPb		
TSOP-50	SnPb	SnPb	Sn	SnPb
PDIP-20	NiPdAu	SnPb		
PDIP-20	Sn	SnPb		
PDIP-20	SnPb	SnPb	Sn	SnPb



# Lead-Free Rework Test Vehicles

Lead-Free Rework				
Component	Original Component Finish	Original Solder Alloy	New Component Finish	Rework Solder
BGA-225	SAC405	SAC305	SAC405	Flux Only
BGA-225	SnPb	SAC305		
BGA-225	SAC405	SAC305	SAC405	SnPb
CSP-100	SAC105	SAC305	SAC105	Flux Only
CSP-100	SnPb	SAC305		
CSP-100	SAC405	SAC305		
CSP-100	SAC105	SAC305	SAC105	SnPb
TSOP-50	SnBi	SAC305	SnBi	SAC305
TSOP-50	SnBi	SAC305		
TSOP-50	SnPb	SAC305		
TSOP-50	Sn	SAC305	Sn	SnPb
PDIP-20	Sn	SN100C		
PDIP-20	Sn	SN100C	Sn	SN100C



# Rework Test Vehicles

## Other Combinations

SnPb Rework		
Component	Original Component Finish	Original Solder Alloy
TQFP-144	SnPb Dip	SnPb
TQFP-144	NiPdAu	SnPb
CLCC-20	SAC305	SnPb

Lead-Free Rework		
Component	Original Component Finish	Original Solder Alloy
TQFP-144	SAC 305 Dip	SAC305
TQFP-144	NiPdAu	SAC305
CLCC-20	SnPb	SAC305



## NASA/DoD Lead-Free Electronics Project

Project Activity	Performer	Number of Test Vehicles Required						Reference
		Manufactured			Rework			
		Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Rwk. SnPb	Rwk. SnPb (ENIG)	Rwk. LF	
		82			74			
Testing Prep								
PWA Assy & Rework	BAE Systems	33	33	16	33	8	33	--
	Apsco Lockheed Martin							
Extra Boards	N/A	2	2	-	2	1	2	--
					Rework Completed by BAE Systems			
Component Characterization	Rockwell Collins	1	1	1	1	1	1	--
					Rework Completed by BAE Systems			
Testing								
Thermal Cycling -55°C to +125°C 30 min. high temp dwell	Rockwell Collins	5	5	5	5	1	5	IPC-SM-785
Rework Completed by Lockheed Martin								
Thermal Cycling -20°C to +80°C 15 min. high temp dwell	Boeing	5	5	-	5	1	5	IPC-SM-785
Rework Completed by Lockheed Martin								
Vibration	Boeing	5	5	5	5	1	5	MIL-STD-810F
Combined Environments Testing	Raytheon	5	5	5	5	1	5	MIL-STD-810F
					Rework Completed by BAE Systems			
Drop Testing	Celestica	5	5	-	5	1	5	JESD22-B110A
					Rework Completed by TT Apsco			
Mechanical Shock	Boeing	5	5	-	5	1	5	MIL-STD-810F
					Rework Completed by TT Apsco			
Post Test								
Failure Analysis	COM DEV Boeing Celestica	#?	#?	#?	#?	#?	#?	--



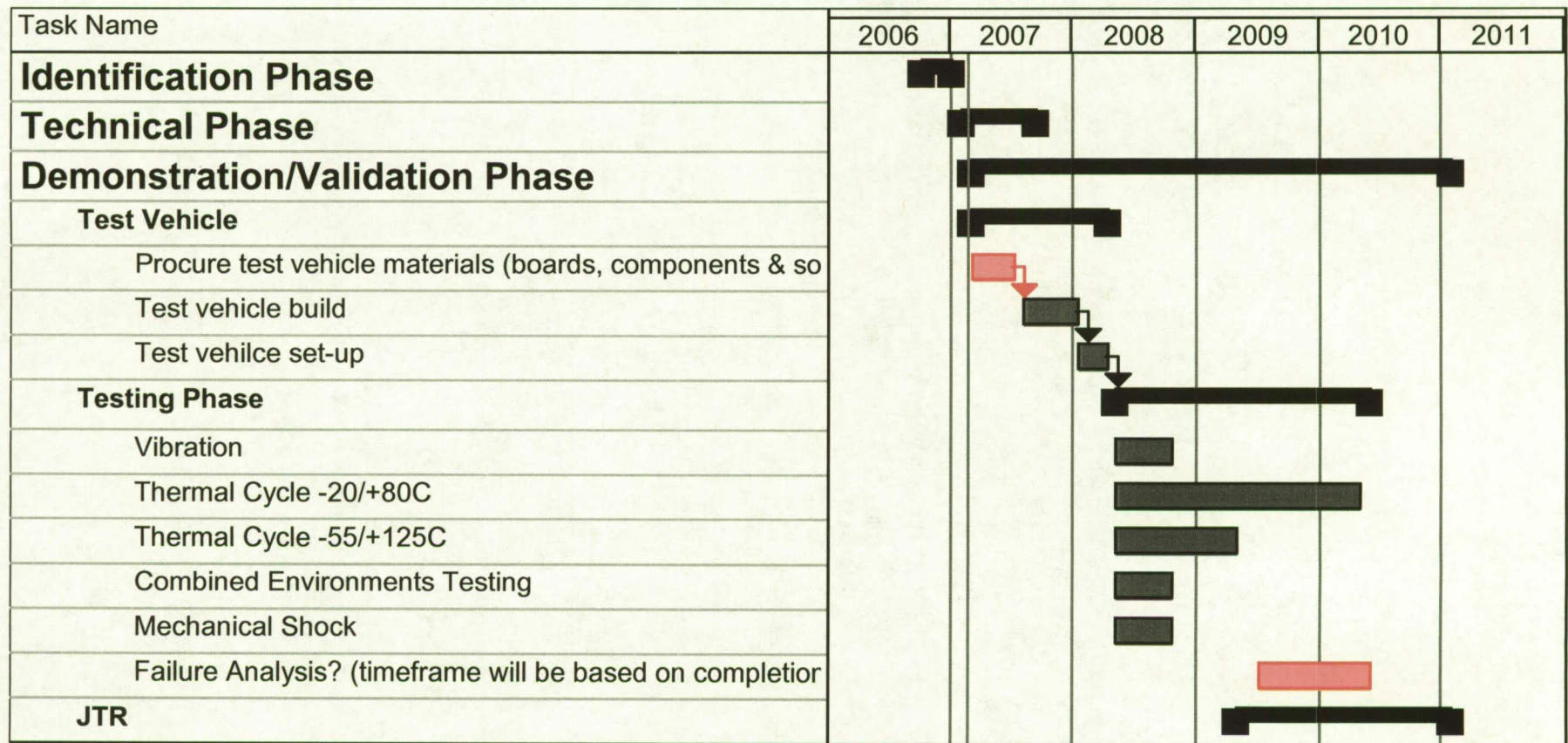
# Project Funding

Project Activity		Performer	Funding Source	Estimated cost		
				Probable Direct Funding	Probable In-Kind Contribution	Funding Shortfall
				\$345,000	\$504,000	\$125,000
Materials Procurement						
Component & Board Procurement	NAVSEA Crane (Gary Latta)	NAVSEA Crane		\$100,000		
Solder Procurement	BAE Systems (Lety Campuzano-Contreras) Apsco (Marcus Wheeler)	In-kind: Solder suppliers Nihon Superior (Keith Sweatman)		\$24,000		
PWA Assembly						
Surface Mount Assembly	BAE Systems (Lety Campuzano-Contreras)	In-kind: BAE Systems		\$150,000		
Plated Through Hole Assembly	Apsco (Marcus Wheeler)	In-kind: Apsco				
Rework	BAE Systems (Lety Campuzano-Contreras) Apsco (Marcus Wheeler) Lockheed Martin (Linda Woody)	In-kind: BAE Systems Apsco Lockheed Martin				
Priority	Testing					
1	Thermal Cycling: -20°C to +80°C	Boeing (Tom Woodrow)	In-kind: Boeing Phantom Works	\$80,000		
1	Thermal Cycling: -55°C to +125°C	Rockwell Collins (Dave Hillman)	NASA	\$80,000		
2	Vibration	Boeing (Tom Woodrow)	DMEA	\$125,000		
3	Combined Environments Testing	Raytheon (Jeff Bradford)	NASA	\$125,000		
4	Drop Testing	Celestica (Polina Snugovsky)	DMEA	\$15,000		
5	Mechanical Shock	Boeing (Tom Woodrow)	TBD		\$125,000	
Circuit Board Reliability Testing						
IST Testing	PWB Interconnect Solutions Inc (Bill Birch)	In-Kind: PWB Interconnect Solutions Inc		?		
Copper Dissolution, PTH	?	?		?		
Failure Analysis						
Failure Analysis	COM DEV (Jelena Bradic) Boeing (Anduin Touw) Celestica (Polina Snugovsky)	In-kind: COM DEV Boeing Celestica		\$150,000		

Funding  
source  
needed!



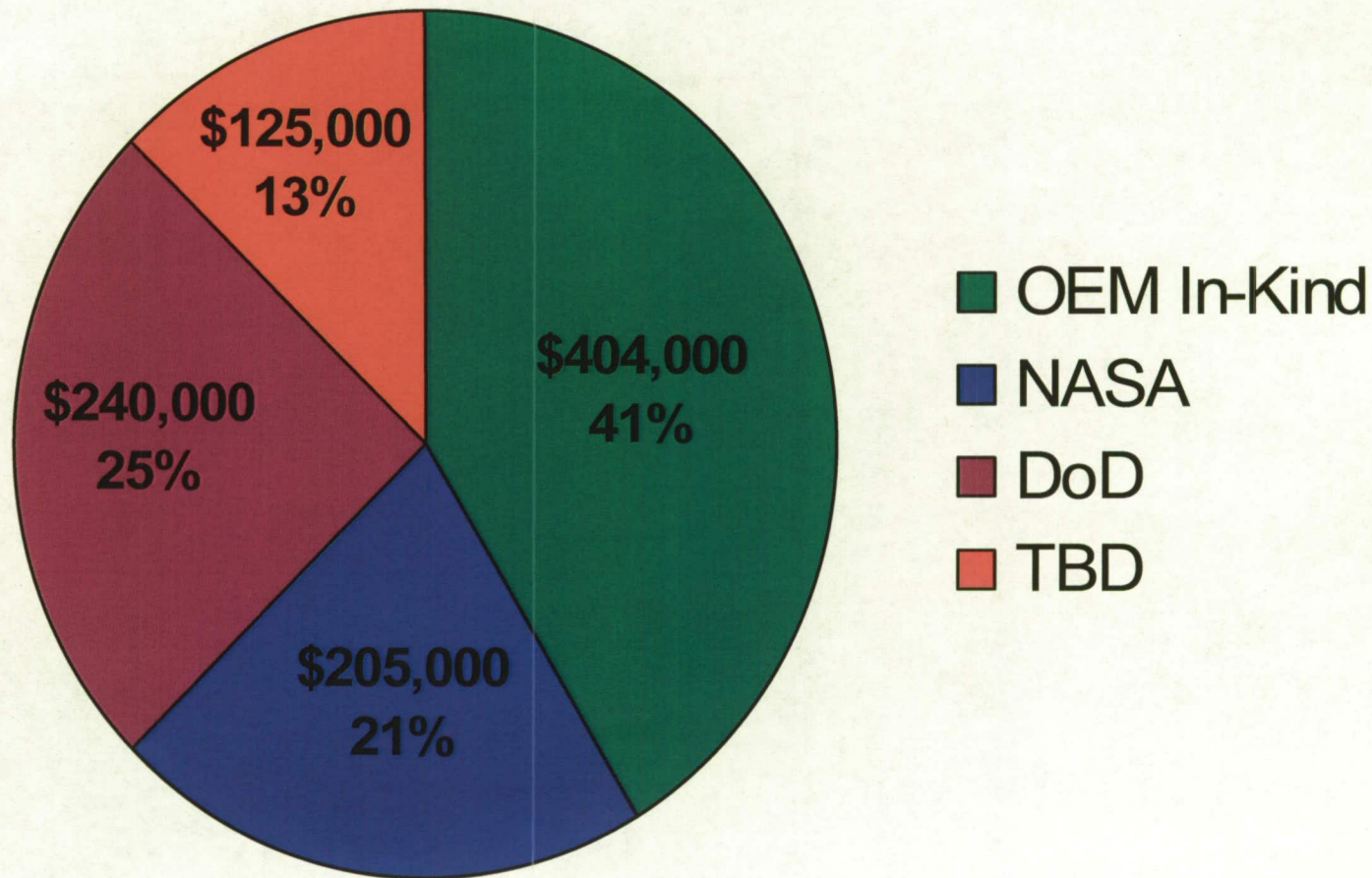
# NASA-DoD LFE Project Schedule



- Currently in the process of procuring components
- Circuit board details are being finalized, board procurement to follow

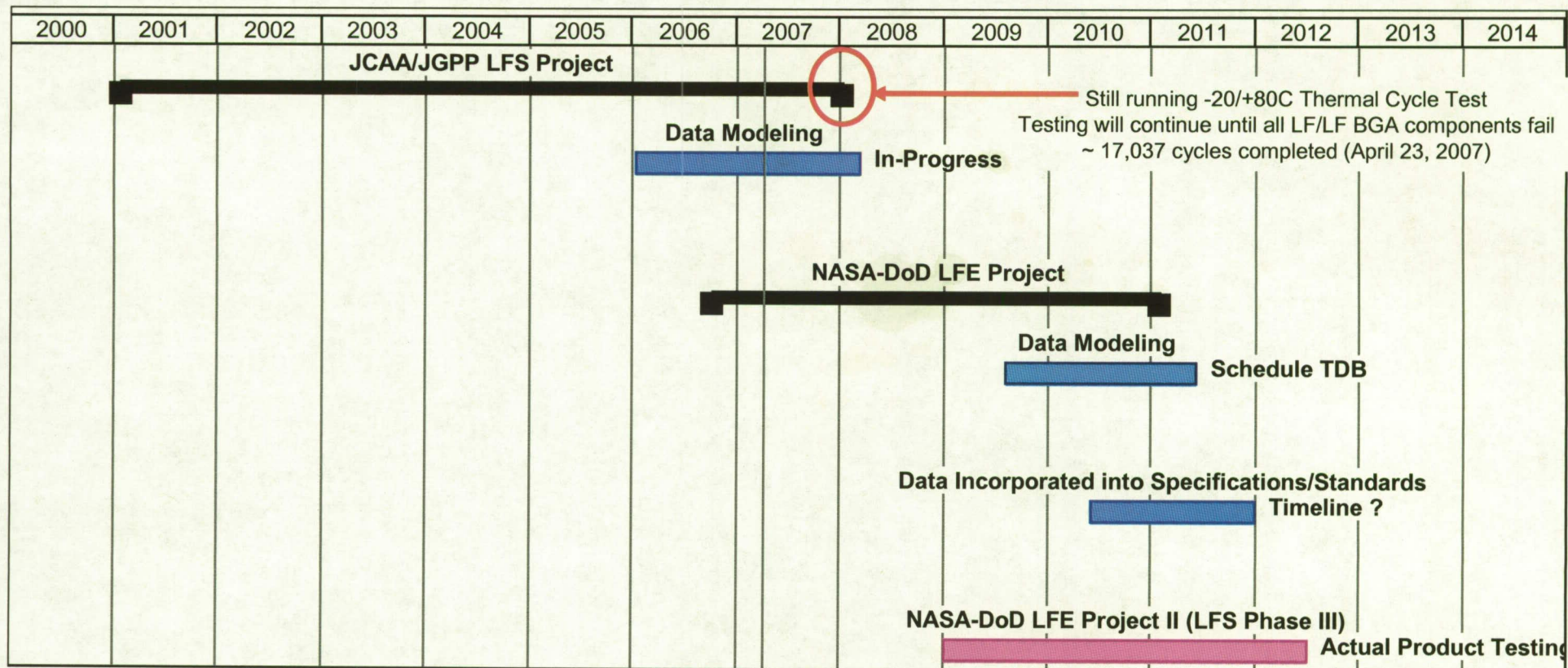


# Contributions to the NASA-DoD Lead-Free Electronics Project





# LF Projects Schedule





# NASA-DoD Lead-Free Electronics Project

**Kurt Kessel  
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**Website: <http://acqp2.nasa.gov>**

## **Web Links:**

**NASA-DoD Lead-Free Electronics Project:**

**[http://acqp2.nasa.gov/projects/NASALeadFreeElectronics\\_Proj2.html](http://acqp2.nasa.gov/projects/NASALeadFreeElectronics_Proj2.html)**

**JCAA/JGPP Lead-Free Solder Testing for High Reliability:**

**[http://acqp2.nasa.gov/projects/LeadFreeSolderTestingForHighReliability\\_Proj1.html](http://acqp2.nasa.gov/projects/LeadFreeSolderTestingForHighReliability_Proj1.html)**